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Case Report

Bailout Endovascular Stent Grafting for an Ascending Aortic Pseudoaneurysm Using an Infrarenal Aortic Extension Cuff

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We report successful thoracic endovascular repair of a pseudoaneurysm rupture in the ascending aorta using infrarenal endovascular devices after an aortic valve replacement. Complete exclusion of the pseudoaneurysm was achieved with no endoleak or postoperative complications. Despite limitations of the current technology, this endovascular technique was a relatively less invasive, feasible lifesaving surgical option for the repair of a pseudoaneurysm of the ascending aorta with a diameter ≤32 mm.

Keywords: endovascular repair, pseudoaneurysm, ascending aorta

Introduction

The standard treatment of ascending aortic pathology is still an open repair because there are no commercially available endovascular devices indicated for repairing the ascending aorta. Endovascular stent grafting is a novel technique that is less invasive than open repair of thoracic aortic aneurysms. However, the anatomy of healthy branches and the hemodynamic characteristics make this approach extremely challenging. This report describes an emergent thoracic endovascular aortic repair (TEVAR) of an ascending aortic pseudoaneurysm using abdominal aortic endovascular devices after an aortic valve replacement.

Case Report

A 72-year-old woman underwent aortic valve replacement using a Mitroflow bioprosthetic valve (Sorin, Saluggia, Italy) 3 months previously was referred with suppurative swelling of the superior margin of the sternum. As incising the swollen area produced pus, a surgical site infection was suspected, and she was admitted. Other physical examination findings were noncontributory. Her medical history included diabetes mellitus and an autoimmune skin disease that treated with low-dose (5 mg) corticosteroid. Laboratory data revealed a white blood cell count of 6.40×10^9/L and slightly elevated 1.42 mg/dL C-reactive protein. The patient was diagnosed with a nonbacterial abscess because repeat bacterial cultures of the pus from her wound were negative. Following a dermatology consult, the steroid dose was increased to 20 mg because of possible exacerbation of the autoimmune cutaneous disease.

The lesion improved with steroid administration and negative pressure wound therapy, but after 2 weeks, the wound exudate became bloody. Evaluation by computed tomography (CT) angiography revealed a large pseudoaneurysm (28 mm) of the ascending aorta (**Fig. 1**). The pseudoaneurysm arose from the puncture site of the cardioplegia infusion needle, and an extrathoracic component of the thrombosed portion had partially eroded the upper margin of the sternum (**Fig. 1**). Several hours after this evaluation, the patient experienced massive bleeding from the wound and temporarily went into shock. Was suspected an ascending aortic pseudoaneurysm rupture requiring emergency rescue surgery. We speculated that the pseudoaneurysm had expanded over the superior border of the sternum. We avoided open surgery via median resternotomy because of the risk of massive hemorrhage and the time required for adhesiotomy and establishing cardiopulmonary bypass. Endovascular treatment was planned.

Preoperative CT angiography revealed the common channel of the brachiocephalic and left common carotid arteries—the "bovine aortic arch"—and the distances from the highest coronary artery to the neck of the pseudoaneurysm (13 mm), the common channel of brachiocephalic and left common carotid arteries (56 mm), and the left

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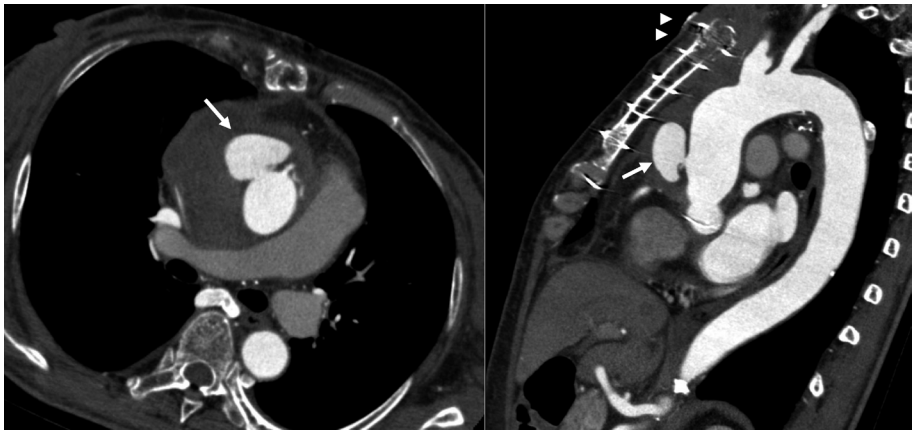

Fig. 1 Computed tomogram angiogram showing a large pseudoaneurysm of the ascending aorta (Arrows). The pseudoaneurysm arose from the mid-portion of the ascending aorta, and its thrombosed extrathoracic component partially eroded the upper margin of the sternum (Arrowheads).

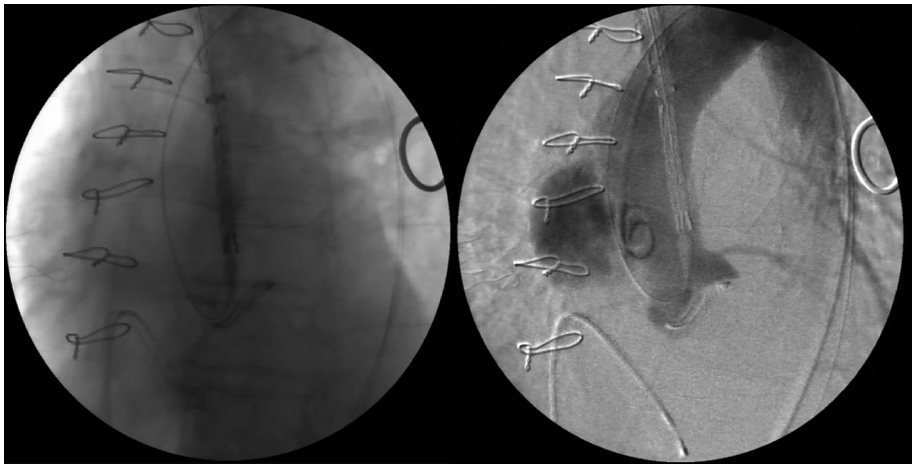

Fig. 2 The stiff wire and device were angled in a "J" shape into the sewing ring of the bioprosthesis, and the stent graft was precisely advanced to the predetermined deploying position of the ascending aorta, preventing injury of the replaced valve.

subclavian artery (71 mm). Even with the shortest thoracic endovascular device, a 77-mm COOK Zenith TX2 Pro-Form Extender (Cook Medical, Inc., Bloomington, IN, USA), the endoprosthesis would cover all supra-aortic vessels and ensure complete aneurysmal exclusion. Nevertheless, configuring an extra-anatomic bypass for a debranching TEVAR procedure can be time-consuming. The diameter of both femoral arteries was 5.7 mm and unsuitable as the access route for an ordinary TEVAR.

However, the diameter of the ascending aorta from the sinotubular junction to the brachiocephalic artery was 30 mm. The sinotubular junction was 30.0 mm, the mid portion was 29.3 mm, and the portion just below the brachiocephalic artery was 29.7 mm. It was thus feasible to use the aortic extension cuff from an infrarenal stent graft system as an emergent TEVAR. Based on the CT angiography findings, a bailout TEVAR procedure using a Gore Excluder Aortic Extender (W. L. Gore & Associates, Flagstaff, AZ, USA) was performed. The surgical procedure was explained to the patient and her relatives, who provided signed consent. Because of the off-label use of the endovascular device, approval of the Ethics Committee of our hospital was obtained.

The procedure was conducted under general anesthesia with the patient in a supine position. We surgically exposed the right common carotid artery (7.1 mm in diameter) and used it as the access route for endoprosthetic insertion of an 18-Fr sheath after administration of 5000 units of heparin. Cerebral perfusion was monitored by near-infrared spectroscopy, and an external perfusion shunt was placed from the right femoral artery to the right common carotid artery to maintain cerebral blood flow.

An initial attempt to advance the device to the sinotubular junction, which was the anticipated proximal

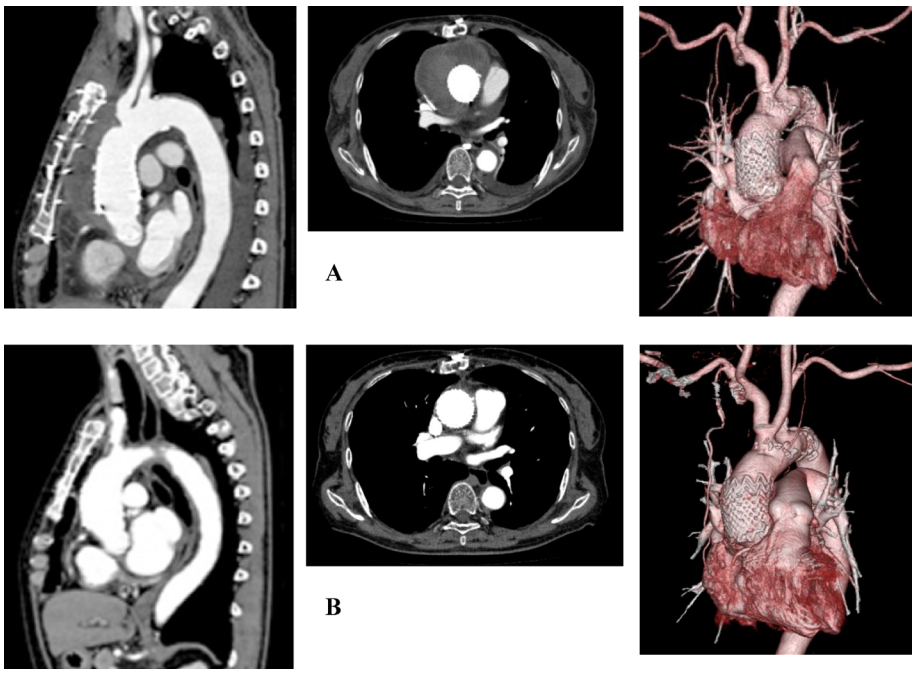

Fig. 3 A follow-up computed tomography (CT) angiogram at 10 days after surgery revealed complete exclusion of the pseudoaneurysm, with no evidence of endoleak (**A**). At the 1-year follow-up, the CT angiogram revealed the elimination of the pseudoaneurysm (**B**).

landing zone failed because the device tip hit the leaflet of the bioprosthetic valve. The "J" shaped stiff wire was advanced through the sewing ring of the bioprosthesis (**Fig. 2**), and the stent graft was precisely advanced to the predetermined deploying position of the ascending aorta. This prevented damage of the previously replaced valve. The endoprosthesis completely covered the orifice of the ascending aortic pseudoaneurysm with 160 beats per minute of rapid ventricular pacing without occluding the coronary arteries or the brachiocephalic artery. Taking into consideration that the radial force of the infrarenal device is weaker than that of a thoracic endoprosthesis, and the characteristics of the ascending aorta, an aortic extender was overlaid several millimeters proximal from the first stent graft. Touch-up of the endoprosthesis was gently performed using a TMP SG Balloon Catheter (W. L. Gore & Associates) without injuring the ascending aortic wall. Angiography at completion of the procedure confirmed exclusion of the pseudoaneurysm without an endoleak.

No postoperative adverse events were observed, and the skin lesions associated with the nonbacterial abscess healed within 2 weeks. A follow-up CT angiogram at 10 days after surgery revealed complete exclusion of the pseudoaneurysm, with no evidence of endoleak (**Fig. 3** Above). The postoperative course of the patient was uneventful at 1 year, and the pseudoaneurysm had disappeared on CT (**Fig. 3** Below).

Discussion

Pseudoaneurysm of the ascending aorta occurs after cardiovascular surgery in approximately 2% of patients.[1] It is a rare and potentially fatal complication and typically occurs at the aortotomy site of the aortic clamp or cannulation, the cardioplegia infusion site, or the proximal side of a graft anastomosis.[2] In our patient, the pseudoaneurysm arose from the cardioplegia infusion site. We think that long-term use of oral corticosteroid had weakened the aortic wall, thereby resulting in the pseudoaneurysm. In such cases, thoracic reentry via a median sternotomy increases the risk of aneurysm rupture and potentially fatal hemorrhage. If open heart surgery with hypothermic circulatory arrest is used to replace the entire ascending aorta, the risk of postoperative mortality increases considerably. For patients at excessive risk of conventional pseudoaneurysm repair, endovascular repair offers a reasonable option.

However, the currently available stent grafts are not compatible with the unique anatomy of the ascending aorta.[3] The ascending aorta is near the coronary ostia and supra-aortic vessels and is typically broader than the descending aorta. It is a curved structure with significant variation in the length of the greater and lesser curvatures. In a few instances, the ascending aorta is long enough to use a 10-cm thoracic stent graft. But in most Japanese patients, adequate coverage is not obtained even with the relatively short aortic extension cuffs the available thorac-

ic stent graft systems, and the risk of obstructing the flow of the coronary and brachiocephalic arteries is substantial. The length of the tip of the TEVAR devices must also be considered. Most TEVAR devices have such a long tip that it is difficult to prevent traversing the aortic valve.

Successful performance of a hybrid TEVAR procedure using an endovascular device and an extra-anatomic bypass, has been reported[4] and compensated for the inadequate landing zone. Perfusion of the neck vessels was restored from the left subclavian artery, descending aorta, and right femoral artery in those patients. In this patient, we avoided the hybrid procedure because it would have taken too long time to establish a debranching bypass. Moreover, the long-term durability of an extra-anatomic bypass after a debranching TEVAR remains unknown.

To overcome these obstacles, we performed the TEVAR with an infrarenal aortic extension cuff, i.e., a Gore Excluder Aortic extender. This endoprosthesis has a short 15 mm device tip, a length of 45 mm, and a diameter of up to 36 mm. It requires an 18-Fr sheath to insert and advance. These characteristics permit deployment of the device to the ascending aortic pathology without covering vital vessels and without being affected by the anatomical features of the ascending aorta. This prevents injury to the prosthetic valve and eliminates the necessity of a hybrid TEVAR. However, for precise graft deployment, temporary rapid ventricular overdrive pacing is necessary because the device does not possess a tip capture function for controlled deployment. One of the disadvantages of this option is that the endoprosthesis cannot be used in patients with large aortas because the largest device diameter is 36 mm.

In the normal ascending aorta, excessive hemodynamic forces cause variations in the diameter. Variation in the anteroposterior and transverse diameters of the ascending aorta during the cardiac cycle was reported as 8.4% and 7.3%, respectively.[5] In our patient, a double-layer endoprosthesis was deployed because such diameter changes could compromise precise deployment and also increase the risk of late migration. The radial force of infrarenal devices is also weaker than that in thoracic endoprostheses.

The thin wall of the ascending aorta does not permit aggressive over dilation. Stent graft deployment was done in most reported cases without any additional balloon dilation.[6] Consequently, only a gentle touch-up was performed for vertical stretching of the stent graft fabric. The walls of the aortic sinus of Valsalva are considerably thinner than the aortic wall. We chose a nonbare stent graft system because devices with hooks or bare springs should not be deployed in the vicinity of the sinus or coronary artery origins to avoid erosion and perforation.

On performing this procedure, access may become a major issue and perhaps a prohibitive limitation. The carotid, subclavian, and femoral (iliac) arteries are considered as access routes. With access from the femoral (iliac) artery, the delivery system, with an entire length of 61 cm, may simply be too short to allow for deployment of the endograft in the ascending aorta. Although the subclavian artery may be preferable for preventing cerebral injury, the diameter of both the right (5.6 mm) and left (5.3 mm) subclavian arteries were too narrow to use. As we had no other option, we chose the right common carotid artery wherein the diameter was sufficiently large (7.1 mm) to allow for device insertion, and the endograft could be inserted forward to the ascending aorta linearly.

In a previous report, Szeto et al.[7] described deployment through a left ventricular trans-apical approach, which is an acceptable option that allows the limited length of the delivery system and decreases stroke risk by avoiding retrograde arch transit of the endograft. However, as they stated, the relatively long time required for lateral thoracotomy and cannulation of the left ventricular apex exposes the patient to increased risk of potential complications including left ventricular apex rupture and injury of intra-cardiac structures, including prosthetic valves. Additionally, the close proximity of the endoprosthesis to the aortic valve during deployment may result in incompetency of the aortic leaflet, thereby causing hemodynamic instability. Surgically, the optimal access route should be chosen considering the anatomy of the ascending aorta and the clinical condition of the patient.

As another surgical option, Hussain et al.[8] reported their experience using the Amplatzer (AGA Medical Corp., Plymouth, MN, USA) atrial septal defect device to treat ascending aortic pseudoaneurysms in six patients. This approach was a partial success, including two technical failures and three instances of minor leakage. We considered this approach in patients in whom we could not traverse the prosthetic valve or could not occlude the vital supra-aortic and coronary vessels. However, in patients with pseudoaneurysm rupture, TEVAR is preferable to the Amplatzer device because an endoleak may result in fatal hemorrhage because complete occlusion of the pseudoaneurysm is required.

Despite a successful outcome, a word of caution is necessary regarding the off-label use of this device to treat ascending aortic pathologies. Limitations involving the anatomy of the aortic root and the ascending aorta, device diameter and length, the presence of infection, and stroke risk must all be considered. However, in cases similar to ours, for whom the risk of open repair was too high, endovascular therapy using an infrarenal device in the ascending aorta is feasible and can be lifesaving. We would like to highlight the importance of having a delivery system with a short tip suitable for each ascending aortic pathology, and more important, flexibility adequate

for both endovascular and open rescue procedures, thus addressing potential complications in high-risk patients. Improved outcomes in patients like ours may be achieved with the development and refinement of new stent-graft devices and delivery systems specifically designed to treat ascending aortic pathologies.

Conclusion

We report successful thoracic endovascular repair of a pseudoaneurysm rupture in the ascending aorta after an aortic valve replacement using an abdominal endovascular device (Excluder Aortic extender). Complete exclusion of the pseudoaneurysm was achieved with no postoperative complications.

Disclosure Statement

Each author has no financial conflict of interest with any organization regarding this article.

Author Contributions

Study conception: YM
Data collection: YM
Investigation: YM
Writing: YM
Critical review and revision: all authors
Final approval of the article: all authors
Accountability for all aspects of the work: all authors

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